UBIQUITOUS ARGONIUM, ArH^+, IN THE DIFFUSE INTERSTELLAR MEDIUM

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ArH^+ is isoelectronic with HCl. The $J = 1 - 0$ and $2 - 1$ transitions of $^{36}ArH^+$ near 617.5 and 1234.6 GHz, respectively, have been identified very recently as emission lines in spectra obtained with *Herschel* toward the Crab Nebula supernova remnant.[a] On Earth, ^{40}Ar is by far the most abundant isotope, being almost exclusively formed by the radioactive decay of ^{40}K. However, ^{36}Ar is the dominant isotope in the Universe.

In the course of unbiased line surveys of the massive and very luminous Galactic Center star-forming regions Sagittarius B2(M) and (N) with the high-resolution instrument HIFI on board of *Herschel*, we detected the $J = 1 - 0$ transition of $^{36}ArH^+$ as a moderately strong absorption line initially associated with an unidentified carrier.[b] In both cases, the absorption feature is unique in its appearance at all velocity components associated with diffuse foreground molecular clouds, together with its conspicuous absence at velocities related to the denser sources themselves. Model calculations are able to reproduce the derived ArH^+ column densities and suggest that argonium resides in the largely atomic, diffuse interstellar medium with a molecular fraction of no more than $\sim 10^{-4}$. The $^{38}ArH^+$ isotopolog was also detected.

Subsequent observations toward the continuum sources W51, W49, W31C, and G34.3+0.1 resulted in unequivocal detections of $^{36}ArH^+$ absorption. Hence, argonium is a good probe of the transition zone between atomic and molecular gas, in particular in combination with OH^+ and H_2O^+, whose abundances peak at a molecular fraction of $\sim$0.1. Moreover, argonium is a good indicator of an enhanced cosmic ray ionization rate. Therefore, it may be prominent toward, e.g., active galactic nuclei (AGNs) in addition to supernova remnants.

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[a] M. J. Barlow et al., *Science* **342** (2013) 1343.

[b] H. S. P. Müller et al., Proceedings of the IAU Symposium 297, 2013, "The Diffuse Interstellar Bands", Eds. J. Cami & N. Cox.